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AUTHOR	Li, Alan L.
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ABSTRACT

Current research into educational technology often uses partnerships between teachers, researchers, and technology designers to study the introduction of new technology in the classroom. However, these partnerships involve commitments of time from teachers and technology reform projects. In addition, these partnerships often focus on student achievement gains measured by student test scores and are not primarily concerned with changes in teacher practice and the difficulty teachers may have in implementing the new curriculum. In this study, a methodology of discourse analysis is developed that is designed to analyze changes in teacher practice as technology is introduced in the classroom. The methodology involves recording and transcribing a complete period of classroom instruction. The verbal record is then divided into coherent segments and these segments are coded using categories that emerge from the actual discourse. The paper provides a case study, using the discourse analysis to investigate the affordances and constraints of technology use revealed by this method. The paper concludes by discussing the implications of these findings for teacher professional development. The coding scheme and five data charts are appended. (Contains 14 references.) (Author/AEF)

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Emerging Patterns of Technology Affordances in Teacher Discourse

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Alan L. Li

University of California, Berkeley

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"Technology Affordances in Teacher Discourse"

Abstract

Current research into educational technology often uses partnerships between teachers, researchers, and technology designers to study the introduction of new technology in the classroom. However, these partnerships involve commitments of time from teachers and professional development provided by researchers that are not always available in large-scale technology reform projects. In addition, these partnerships often focus on student achievement gains measured by student test scores and are not primarily concerned with changes in teacher practice and the difficulty teachers may have in implementing the new curriculum. In this study I develop a methodology of discourse analysis designed to analyze changes in teacher practice as technology is introduced in the classroom. The methodology involves recording and transcribing a complete period of classroom instruction. I then segment the verbal record into coherent segments and code these segments using categories that emerge from the actual discourse. I provide one case study using the discourse analysis to investigate the affordances and constraints of technology use revealed by this method. I conclude by discussing the implications of these findings for teacher professional development.

Point of Contact:
Alan L. Li
4533 Tolman Hall
Berkeley, CA 94720-1670
cheddar@uclink.berkeley.edu

IR021422

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Objectives and Theoretical Background

How can teacher practice with the Web-Based Integrated Science Environment (WISE) be enabled so that teachers will adopt the technology as part of a large-scale reform effort? WISE is one of many learning environments developed at major research institutions based on current cognitive research. The technology guides student learning through cognitive scaffolds contained in the user interface such as inquiry maps, data visualization aids, and graphical modeling tools. These scaffolds allow students to integrate classroom knowledge with previous ideas constructing new understandings about science and other domains. However, Fishman et al. (2001) note that while these new technologies are often integrated successfully in small-scale research classrooms, schools resist these reforms if they are part of school or district wide reform programs. This paper explores the context of large-scale technology reforms and looks specifically at methodological challenges to conducting research across multiple classrooms and teachers in educational technology implementations. The discourse analysis protocol developed here can be used in future studies to investigate more specific questions such as how teacher practice changes in response to the introduction of visualization and modeling tools and how this informs the design of professional development programs over multiple years of implementation.

Computers and Internet capable media centers and classrooms are being introduced in public schools across the United Sates. Cattagni & Westat (2001), in a report prepared for the U.S. Department of Education, note that while only thirty-five percent of public schools were connected to the Internet in 1994, ninety-eight percent were connected by 2000. Additionally, by the year 2000, the ratio of students to Internet capable computers in public schools had dropped to seven students per computer. This ratio is low enough for many schools to build and equip

shared computer labs or to place a handful of Internet capable computers directly in teacher's classrooms.

With this increase in classroom hardware comes an increasing amount of educational software from major research institutions. Research groups within universities design this software from their own pedagogical affiliations bringing an often-transparent teaching partner with them. Pea (1993) states, "...tools literally carry intelligence in them, in that they represent some individual's or some community's decision that the means thus offered should be reified, made stable, as a quasi-permanent form, for use by others" (p.52). In other words, technology itself is not simply a tool that teachers can use seamlessly within their curriculum replacing a book or a piece of lab equipment. Instead, computers and educational software bring with them both designed and unintentional affordances and limitations that change classroom activity through their implementation. In effect, technology can be viewed as a classroom reform introducing new equipment and pedagogy simultaneously.

Brown (1992) acknowledges the difficulty of studying the interaction between technology and its introduction in the classroom when she writes, "Just as it is impossible to change one aspect of the system without creating perturbations in others, so too it is difficult to study any one aspect independently from the whole operating system" (p. 143). Again, one sees the idea that technology is not simply a tool a teacher can plug in and turn on. A computer and the Internet are pieces of classroom technology that bring with them pedagogical influences that will only fully express themselves within the context of an actual classroom environment.

In order to study the changes in classroom practice associated with the introduction of technology, universities have often used a partnership model to introduce their classroom interventions to teachers and students. These partnerships bring together teachers, researchers,

and subject matter experts to develop communities of practice such as those of WISE (Linn et. al., 1999) (see also, Shrader et. al., 1997). In these communities of practice researchers and teachers implement technology reforms, changing teacher practice through professional development in technology skills and reform pedagogy.

However, moving educational research from educational psychology laboratories to the dynamic and unpredictable school classrooms where technology reforms unfold has required researchers to formulate new methodologies appropriate to analyzing these environments. Design experiments (Brown, 1992) have allowed researchers at many universities (Blumenfeld et al., 2000, Linn & Hsi, 2000, Fishman et al., 2001, Shrader et al., 1997) to introduce a technology interventions in the classroom and, through an iterative design process, improve the technology and its implementation to the point where teachers can use the technology effectively to improve student achievement measured by pre/post test scores.

However, small-scale design studies often prove less than adequate for looking at large-scale systemic reform programs. Fishman et al. (2001), in summarizing their work across multiple schools and teachers in the Detroit public school system, state, "...work on public school reform is not well informed by research to date on technology and learning...this is not the result of flaws in the research as it was conducted. Rather, it is a consequence of the intent and the paradigms under which that research was conducted" (p. 18). In their analysis, they note that, "current research in technology for learning is focused on the design of technology and on questions about whether or how technology influences learning" (p. 18). They call for a shift in focus to, "questions about how to enable the use of technology in regular classrooms" (p. 18) and a shift in magnitude away from single classrooms and teachers to multiple participants involved in systemic reform. Fishman et al. are careful in their critique to reiterate the necessity and validity of smaller

scale laboratory and design experiments. These experiments are important to the development of new technologies and a refined understanding of the learning process. However, they stand firm in their conclusion that effective systemic reform efforts must be informed by research into culture, capability, policy, and management issues across increasing numbers of subjects and participants in systemic reform implementations.

This paper addresses one aspect of research in large-scale technology reform implementations. In order to understand how to enable teachers to use educational technology in systemic reforms, it is necessary first to design an adequate measure of teacher practice and be able to compare this measure across large numbers of teachers and schools. This common measure would allow researchers to quantify how teacher practice changes and evolves in response to technology over the course of a reform. The purpose of this study, then, is to explore a methodology for analyzing the affordances and constraints on teacher practice once a technology is introduced in the classroom.

First, I look at how teacher practice is often analyzed in technology reform research projects and how discourse analysis can be used to quantify important patterns in teacher practice that previous methods could only uncover indirectly. Next, I look at the WISE technology in detail and at the affordances that the WISE research group designed into the software in its development. Finally, I use a case study of one teacher's practice to illustrate the use of this form of discourse analysis in analyzing how the teacher modifies his practice in response to the introduction of the WISE reform into his classroom. The teacher's classroom discourse is coded and analyzed as an indicator of differences in teacher practice with and without the technology present. From the patterns in teacher practice observed, a set of technology affordances and constraints emerges. The conclusion of this paper will explore the potential uses of this

methodology in further research within the context of technology professional development programs.

Teacher Practice Indicators

Tyack and Cuban (1995) view teachers as integral to the introduction of a reform into schools. One reason is that teachers are central agents in a school culture that modifies and in many cases subverts classroom reform efforts. Tyack and Cuban write, "As 'street-level bureaucrats,' teachers typically have sufficient discretion, once the classroom doors close, to make decisions about pupils that add up over time to de facto policies about instruction" (p. 135). Shrader et al. (1997) use the term lethal mutations to describe points where teachers modify technology reforms so they no longer function as intended by the original designers.

However, as noted earlier, much of the research into technology reforms focuses on the cognitive effects of technology on learning. As a result, this research often focuses on students instead of teachers. Pre/post tests assess student achievement. Researchers perform student cognitive interviews and detailed ethnographic descriptions of students working collaboratively with technology. What evidence there is of teacher interactions with technology reform comes in the form of teacher interviews with researchers using interviews to indirectly infer the importance of small segments of teacher practice recorded on video tape or in field notes. In all of these approaches, the collective effect of teacher-student interactions over a complete 40-50 minute teaching period remains largely unanalyzed. More detailed descriptions of teacher practice such as the first person narratives of Ball (1999) make comparisons across teachers, schools, and districts problematic because of the lack of data quantification.

Methodology

The method I use to capture teacher practice involves recording the teacher discourse for the full duration of a class period. What the teacher attends to in their verbal interaction with students can be used as a key indicator to determine teacher classroom practice. I used guidelines developed by Charmaz (1983) and Chi (1997) to breakdown and code the transcripts into analyzable segments. Chi (2000) uses verbal analysis to study such cognitive processes as how students make sense of text material through self-explanations. In verbal analysis, the focus is on knowledge representation and how this representation determines a problem solving process. Although the discourse analysis I use in this research does not share the same goals as Chi's verbal analysis, it does benefit from the detailed coding and analyzing methods that Chi (1997) uses. Recordings from six forty-six minute periods generated a large amount of verbal data that was reduced, segmented, coded, interpreted, and reinterpreted using Chi's general verbal protocol.

In addition, since I could find little guidance from the literature about useful coding strategies for discourse analysis concerning teachers using classroom technology, I had to develop coding guidelines borrowing from work in grounded theory methodology. In the grounded theory method according to Charmaz (1983), data collection and analysis proceed simultaneously with initial data and analytic interpretations sharpening later observations. In this way, the products of research are shaped from the data rather than preconceived logically deduced theoretical frameworks. This emerging theoretical framework as work with the data progresses is a key component of grounded theory work. While I did not follow the simultaneous data collection and analysis protocol as closely as a grounded theorist would, I did go through multiple segmentations and reinterpretations of the data allowing the eventual coding scheme to emerge

from the data itself. The major advantage of this process for my research is that I did not need a preconceived coding scheme when starting my observations. My final coding scheme emerged from the data as I collected it and represents an interpretation of the actual teacher discourse that occurred in the classroom. The major drawback of this methodology for my research is that my coding scheme was somewhat limited by what I observed the teacher saying. Therefore, in such a limited case study, the coding scheme remains a work in progress and will need a wider range of teacher data and refinement before it becomes more generally useful as an analytic tool.

The coding scheme allowed me to see emergent categories in the teacher discourse with each new review of the data. Large grain size categories such as discourse directed at the whole class or individuals and small groups were eventually refined to the nine content subcategories and ten classroom management subcategories of this study. In this manner, the entire six-day discourse record was coded and the results of the teacher discourse teaching with and without the WISE technology analyzed. Appendix 1 explains the final coding protocol I used in detail.

Reform Technology

WISE was developed through over a decade of research at the University of California, Berkeley into computer-assisted curricula using the Scaffolded Knowledge Integration (SKI) framework based on constructivist and inquiry pedagogy. Using WISE, teachers are expected to guide students through a learning environment where students integrate information gained through their instruction to previous knowledge making new ideas more accessible, take advantage of opportunities for social learning contained in the classroom, develop visualization abilities to become more aware of their own thinking processes and those of their peers, and develop methods of inquiry that they can transfer outside of the classroom on the path to becoming life long learners (Linn et al., 2000). Therefore, WISE was designed to work with

teachers who help students to construct their own scientific understanding through investigations of scientific controversies relevant to the students' interests. The teacher is also expected to guide students through learning from each other as the teacher walks from group to group, prompting students to engage in discussions about the WISE content. Finally, the teacher should help the students adopt effective inquiry and evidence analysis abilities through modeling and guiding the students through metacognitive awareness of their own thinking processes.

Figure 1 in Appendix 3 shows a sample screenshot from the WISE learning environment. Inquiry scaffolding occurs through the sequenced menu on the left hand side of the largest window where students navigate through an inquiry process. The notes window allows collaborative pairs of students to engage in metacognitive discussions of their understanding about particular content in a lesson. The hint window supplements teacher assistance by providing a ready resource of cognitive scaffolds to guide students through the project. The WISE environment is one of many learning environments based on cognitive research and described by Fishman et al. (2001) as technology tools that scaffold complex investigation processes for students.

To support teachers in guiding students through this constructivist pedagogy, the WISE research group has a professional development plan based on a working partnership with teachers that designs and customizes the curriculum to the teachers' own needs. This plan also provides opportunities to see master teachers model expected teacher classroom practice (Linn et. al., 1999). I initially designed this study to look at a teacher who used the WISE technology as part of a learning partnership. However, I soon encountered problems in securing adequate teacher professional development time similar to the situations in Blumenfeld et al.'s (2000) attempt at systemic reform in Detroit schools. Except for an introductory one-hour meeting a month before

the planned six-day classroom observation, the teacher refused all offers to develop a customized curriculum or to meet with a master teacher to discuss changes in teacher practice. The teacher also proved very difficult to contact up to a week before the observation. Two days into the unit, the teacher self-reported that he had not looked more than a third into the actual curriculum and was not even aware of elements contained in the curriculum such as details of Internet evidence pieces or the ability of the students to conduct whole class electronic discussions. This lack of teacher preparation provided the opportunity to conduct this case study of a teacher implementing the WISE genetically modified food unit in their classroom with minimal professional development support during the three days in the school's computer lab using WISE.

The School

I conducted this case study in an urban high school near San Francisco, California. The teacher I worked with, who I will refer to as Mr. T, teaches three periods of a course in environmental science taught to students in their junior and senior years. The teacher has six years of experience teaching biology and physical science at a nearby urban high school. However, this is the teacher's first year at the school used for this study, which I refer to as Bayside High School. Mr. T has taught previous courses using technology such as PowerPoint or CD-ROM based informational databases. The WISE curriculum is the first instructional environment Mr. T has encountered that integrates constructivist pedagogy, activity scaffolds such as student notes and online chats, and curricular content in a single software package. I followed the teacher and his twenty-two student second period class for six days while they studied a unit on genetically modified foods. Chart 1 in Appendix 2 summarizes the six-day instructional period. For the first three days, the students used an Internet based inquiry project

on genetically modified foods that is part of the WISE learning environment. The WISE instruction occurred in Bayside's computer laboratory.

The final three observation days took place in the teacher's own classroom. The teacher conducted a lecture discussion using his own materials on genetically modified foods on the first day after the WISE unit. Mr. T introduced a four-page excerpt from a book describing the development of agriculture from as far back as 8,500 BC followed by a lecture on how humans have modified plants from ancient times to the present. He then spent the last part of class organizing students into workgroups who would present pro or con oral position arguments to the whole class on the sixth and final day of the research period. The students started working in their groups at the end of the fourth day to prepare for their presentations. On the fifth day, the students continued their presentation preparations in groups using the WISE evidence and lecture material to support their positions. At the beginning of class, the teacher distributed a nine-page Time article to the students on genetically modified rice. However, Mr. T spent most of his time during this class period updating student grades and returning past student assignments leaving the students to, in his terms, "self-motivate".

The teacher wore a lapel microphone for the entire six-day period and a complete audio record of the teacher's discourse was taped and transcribed. I compared the audio record with field note observations when it was not clear to whom the teacher directed his comments or what other contextual characteristics the discourse occurred in. However, voice inflection and the transcript were sufficient in most cases to segment and code the audio record.

Results

This results section includes the types of interaction patterns that emerged during the coding of the six-day sequence of classes. The first types of discourse that emerged from the data

concerned whom the teacher directed his discourse toward. In observing Mr. T in his classroom, there were times when he moved to a central location, quieted the class, raised his voice, and addressed the class as a whole audience. At other times, the teacher let the class proceed with their individual activities while speaking to an individual or small group of students. Chart 2 in Appendix 2 illustrates the percentage of class time spent in whole class discourse, individual/small group discourse, or not talking. Two examples from the second day using WISE in the computer lab show the contrasts between the two types of discourse:

> Hey folks listen up please. Shhhh. Read over this, this is crucial. 75-point assignment. Shhhh. Your job is to write a science based three page typed essay. This is the last major writing assignment of the year for you folks...
>
> Coded: Whole Class Classroom Management (Procedure)
>
> You know, I'm gonna ask you to put that away please and work on this, ok? You two go ahead and logoff. [Student logged off.] Well, get back to the thing you're supposed to be working on for this class. [Student didn't want to.] Okay, then you are gonna go over there and just not use a computer, ok?
>
> Coded: Individual/Small Group Classroom Management (Discipline)

The results show that at this level of analysis, the results are very uniform for the three days of instruction with WISE. Individual/Small group interactions were very high within a range of seventy one to eighty percent of the total teacher discourse on those days. In contrast, the teacher engaged in whole class discourse less often in a range between eleven and nineteen percent of the total teacher discourse.

On days when Mr. T taught without the WISE technology present, the results were far more variable. A lecture discussion on the fourth day increased whole class directed talk to half of the total teacher discourse. Individual/Small group time decreased to only 19 percent. On the fifth day, the ratio of whole class to small group discourse time was similar to the WISE days,

although most of this shift from whole class to individual/small group discourse came from the teacher talking to individual students about their grades and assignments. The sixth day, the teacher was listening to the group presentations. However, he addressed most of the comments he did give to the class as a whole. Across all six days, Mr. T spends the most time engaged in individual/small group discourse on the three WISE instructional days.

The next step in my coding of Mr. T's verbal record was to move from consideration of his audience to a breakdown of his discourse by subject. Again, I chose a large grain size for the initial coding scheme. I decided to code the discourse segments into those that referred to classroom management, those that referred to course content, and those that referred to neither subject.

Classroom management discourse refers to talk related to the administrative goals of a classroom. The teacher used classroom management discourse to organize student workgroups and grades, maintain classroom discipline, and to prepare students to begin and continue classroom activities. Several examples of classroom management discourse follow:

> So um, here's the start up website. You need to go into join WISE. So you're basically going to join on and become part of their group there. The student registration code is xxxxx. And then you choose the password, I would say choose something that you won't forget like your student ID number. So select choose password.
>
> 1st day using WISE. Coded: Whole Class Classroom Management (Procedure)
>
> Hey, how are you guys doing? You are at this? So did you guys...so you guys are pro. And, you've been going through it step by step and everything? Okay. So you're at the point where you are gonna defend your position, your last point? Okay, just check. You can print this out tomorrow.
>
> 2nd day using WISE. Coded: Individual/Small Group Classroom Management (Maintaining Student Progress)
>
> Yeah. If you can't log under...using your own name... Who's your partner? Well, see if I log you on, then you can't print here. Do you have a printer at home? If you have a

printer at home, just go to this website, write this down, wise.berkeley.edu, and you can use...you can print it. No, you can print it out tonight at home. Ok. Yeah, you are gonna use it in class tomorrow, so.

3rd day using WISE. Coded: Individual/Small Group Classroom Management (Troubleshooting)

Ok, let's see. I was bored when I was getting on the plane to Norway and I knew it was going to be a long flight. So, I looked in the bookstore, and I lucked out. I have a hard time finding books that I like. I don't know why, you know, too picky, and I am not smart enough. But this one here just knocked my socks off. This is a great book. It's called Guns, Germs, and Steel. It's written by a professor of physiology at UCLA. And he's what you would call a, I would call him this; I would call him a polymath. Anyone know what a polymath is? Poly means many and in this case math, I'm not sure why it comes out this way, but when you say polymath, somebody who's like, he knows a lot about a lot of different fields. Another way is you can call him a renaissance man. You know, whatever. He knows a lot about a lot of different areas. And in it, in his book, he doesn't just stick to physiology or even biology. He strays into anthropology. This guy lived with Papua New Guineans for like years and years and studied them. So he's backed up some of his book learning with practical real life experiences. So this book is great, it talks about how basically civilization arose, because of a couple of factors. And if you can tell from the title, what do you think three of the factors are? Ok, so, so the ability to wage war. Right? Guns, Germs. Germs, that's a tough one. Viruses, ok.

4th day lecture discussion. Coded: Whole Class Classroom Management (Introduction)

Ya. Um...where's your um, where's your...let's see, ok, see you were really close to uh to...they don't let you put like pluses or minuses on report cards at this school. So what counts though is the semester grade. So like the quarter grade doesn't even go on your transcripts. Well, I can't...I mean I basically go by what this tells me here. I mean, I think this for instance, hadn't been turned in. I just gave you credit for that. Um, you must have been missing just enough assignments to drop you down. And now it looks like you got 'em all in with the exception of this one here. Eighteen. So that's from the book, those readings. That questions there. Page 365. So I mean what I would say is that huh, next huh, the next semester grade is what you're really concerned about because that's what you're going to show colleges and stuff. You know, kick butt. And turn in all the stuff and then get an A on that semester grade. Ya?

5th day presentation groups. Coded: Individual/Small Group Classroom Management (Reporting Organizing Grades)

Course content discourse refers to talk related to the core themes and information that the teacher wants the students to learn. Content information includes not only explanatory text and

lecture information but also information on how to integrate, validate, and report this content to others. I have included several examples of content discourse below:

> Just based on whatever you feel right now. That does not mean after you've researched it, and after you've cemented your position. Based on what you've read, what you…your gut reaction. Would you eat genetically modified foods?
>
> 1st day using WISE. Coded: Whole Class Content (Prompting)
>
> And what I would like you to do is use facts to support your opinions. Okay? So when I say science based, I mean that you come up with a statement like: "I think environmentally engineered foods suck…" Well, then I need some evidence. I need some backup, scientific backup for your statement. If you just say it sucks then you don't get any credit. You gotta like tell me why it sucks. So, in this essay you defend your opinion either pro or con, genetically modified foods. And you can take it to the global level, or you can keep it on the U. S. level. Okay? I don't care. I think that the global level is what's important, because ultimately global issues are what count, I think. Opinions should be supported by facts and quotes. Okay? What does that mean? Opinions should be supported by facts and quotes. Let me give you an example for that. How many of you guys know what attribution is? When you like make a statement and quote somebody… there you go…you have to give the full name and title of the person who is backing up your point of view. So like the more people that you can quote like professors of agronomy which is the study of grasses, the better your paper will be.
>
> 2nd day using WISE. Coded: Whole Class Content (Evidence)
>
> The extension of that is that if it does it to the rat it will do it to a person. But then on the pro's side, you gotta, you know, also question…well, not just that but check out the research to see if it was really a fair study. What, I mean, did they feed this thing the equivalent amount of five thousand bushels of corn a day, or how much did they do it. Actually it was potatoes. It was genetically modified potatoes.
>
> 3rd day using WISE. Coded: Individual/Small Group Content (Validity)
>
> Ok, go ahead and start discussing this. So, um, if you look at that table, how long has human agriculture been going on? What are the approximate dates? Ok, 8500 B.C. That really doesn't mean that there wasn't agriculture before that, but we don't have evidence of it. And guess where the evidence comes from for these dates? What's that? What was that? Fossil? Ok, um, in a sense fossils. Excavations, yes. Archeological sites. They go back into places like Syria and Jordan and start digging for… well, for the most part, digging. And they'll find, say, some seeds. Maybe they'll find the remains of a campfire. And then how do they apply dates to those? Does anyone know? Yeah, it's called radioactive carbon dating. It turns out that there is, in the atmosphere around us, there are

many isotopes of carbon. And two of the most…one of the most common is C-14…(This is a partial quote of a much longer segment.)

4th day lecture discussion. Coded: Whole Class Content (Lecture Discussion)

No, this isn't that hot an issue. When we start debating cloning, whooa. I mean that's why the tempers start to flare and I watched these debates in the congressional committee…

6th day presentations. Coded: Whole Class Content (Controversy)

Chart 3 in Appendix 2 shows the teacher's discourse segmented by classroom management and content categories. It clearly shows that classroom management takes up the majority of the teacher's time on all three WISE instructional days. Teacher content discourse is low even in the lecture discussion period. The time the teacher devotes to course content discourse never rises above the lecture discussion day peak of 29% while falling into the single digits on the third and fifth days. As before, while the WISE days are more uniform, the non-WISE days are more varied in the segmentation of teacher discourse time. During the WISE classroom days, classroom management discourse dominates each class period. In the lecture discussion period, classroom management, content, and not talking each take up about a third of the teacher discourse time. For the grading and group presentation preparation day, classroom management is again prominent. Finally, on the last day, the teacher is mostly silent as he listens to presentations.

The final coding scheme that emerged from this study was the breakdown of classroom management and content into more specific categories. These categories are explained in detail in Appendix 1 and the examples given so far include many content item codes. These additional categories help to explain broader trends from the more general categories. For example, looking at the content break down in Chart 4 Appendix 2, one can see that content discourse was

somewhat stable the first two days of the WISE periods, then it dropped to only 5% of total class time the third day. The classroom management chart (Chart 5 Appendix 2) explains this drop in content time as both troubleshooting and maintaining student progress classroom management time increased dramatically on the third day. This was the period where students were finishing their WISE projects and trying unsuccessfully to print their results. Also, the classroom management chart shows high classroom management discourse levels for the three days of WISE use and the presentation group preparation workday period. However, a breakdown of the classroom management into subcategories reveals that the three WISE periods were composed of discourse in response to random classroom events such troubleshooting and maintaining student progress within the software curriculum. In contrast, the management during the group preparation workday was in large part due to a planned grade reporting and organizing period. Finally, the fourth day was made up of lecture and lecture discussion content rarely seen on the other days in this study. Likewise, the lecture discussion day lacked the differentiation in content found in most of the other class periods. While this may point to a need to differentiate the lecture and lecture discussion categories as the coding scheme is applied to more teachers and classroom events, it also points to qualitative differences in the types of discourse present in lecture discussion and what are essentially student centered periods in the other five classes.

There is also some evidence here that the teacher uses the extra personal time with students to socially bond with students in talk unrelated to content or management. Time talking about such topics as his vacation or students' college plans takes up much of the balance of time on WISE days at between twenty and twenty-eight percent while unrelated talk makes up only eleven percent of the lecture discussion day. This suggests that affordances in teacher practice provided by technology, such as individual and small group discussion time, may not be used as

the designers of the curriculum intended. This finding also illustrates the need to take the discourse analysis methodology developed in this study and apply it to student discourse. If Mr. T only spends at most twenty-two percent of his time talking to students about course content during the WISE technology days, then a study of student discourse as they work in pairs should prove revealing to see if WISE technology scaffolds the students to work with the content independent of teacher guidance.

So a picture emerges of technology affordances and constraints while using the WISE technology compared to instructional days without WISE. While the teacher conducts the first three days of the unit, he spends more time in classroom management discourse, guiding students through technical procedures and troubleshooting technology problems. He also spends more time in individual and small group discourse compared to classes where he lectures. In contrast, the teacher's lecture discussion class has more concentrated time devoted to course content addressed to the whole class with less time spent in classroom management or in unrelated social bonding discourse. For this teacher, the WISE technology provides opportunities to shift his discourse time to individual student needs as well as social bonding discourse while at the same time requiring him to devote more time to troubleshooting the technology itself.

Implications of the Revealed Patterns for Reform Pedagogy

The WISE learning environment was originally designed to foster student knowledge integration where students reflect, reorganize, and reconnect their ideas based on integrating new knowledge with previous experience. An important role for the teacher in knowledge integration is to model knowledge integration behavior and to prompt students to talk about their ideas so that the teacher can assess their understanding and the students can reflect on their own thinking. This requires the teacher to roam the classroom and engage in one-on-one conversations with

students to gain a deeper understanding of student thinking processes than would be possible if the teacher remained at the front of the classroom in whole class discussion. For many teachers, this is an important pedagogical shift they must make before they can use elements of the WISE learning environment to promote knowledge integration.

Surveying the discourse audience data for the three WISE days, it appears that one important affordance of the reform technology is the scaffolding that WISE provides for teacher interactions with small groups of students. The teacher showed a clear pattern of engaging in individual and small group discussions with students in over seventy percent of the class time during the days he spent teaching with WISE. In contrast, when the teacher was in his own classroom in a combined lecture and group workday, he spent just nineteen percent of his time engaged in discourse aimed at individuals and small groups.

In addition, the teacher was performing administrative tasks in his classroom when he let his students "self-motivate" while he read quietly at the front of the classroom, recorded information in his grade book, or passed back student assignments. During the days he used WISE, this time of administrative silence decreased from a peak of thirty-one percent on day four (excluding the presentation day when the teacher would be expected to have long periods of silence while listening to student presentations) to as little as two percent on the second WISE day. While it is important not to minimize the need that a teacher has for conducting administrative tasks during class time, it appears that while the teacher let his students work in groups with minimal progress monitoring in his own classroom, he engaged in more individual attention to groups in the computer lab. Mr. T used this additional attention to monitor student progress within WISE or to socially bond with his students in casual conversations.

Looking at the breakdown of content time during the first three days, it appears that the teacher also engaged the students in content conversations covering the knowledge integration topics reflected in the WISE unit. He spent this content time on argument, controversy, evidence, and prompting students for their ideas. These themes recur during the last day as he comments on student presentations.

While this shift toward individual and small group interaction and WISE content themes provide increasing opportunities for the teacher to engage in knowledge integration activities while working with WISE, two factors seem to work against the knowledge integration discourse. The first appears to be a constraint of the WISE technology on teacher practice. The teacher engaged in discourse related to classroom management in over half of the available time in the WISE class periods. Clearly, this time spent in explaining procedures, keeping the students engaged in the software, and troubleshooting technical problems like printing on the third day place serious time constraints on the ability of the teacher to engage in content discourse encouraging knowledge integration.

The second factor working against knowledge integration discourse occurs in the choice the teacher makes when provided with opportunities for individual and small group discourse. On the days with the highest individual and small group directed discourse, the teacher also has the highest incidence of social talk with students. During this social time, the teacher often engaged in discussions about his vacation or other social "bonding" topics. The combined effect of classroom management constraints and increased affordances for social talk reduced the actual time spent on content to just under six minutes or less on all three WISE days.

Implications for Professional Development

As noted before, many current investigations develop communities of practice that enable researchers and teachers to implement technology reforms, changing teacher practice through professional development in technology and reform pedagogy. However, such communities require time commitments from teachers that are not always available. Teachers may not be willing or may not be able to read through the reform curriculum or to attend after school workgroup meetings and weekend workshops that are part of community partnerships. The President's Panel on Educational Technology (1997) found, "...teachers currently receive little technical, pedagogic or administrative support for these fundamental changes, and few colleges of education adequately prepare their graduates to use information technologies in their teaching. As a result, most teachers are left largely on their own as they struggle to integrate technology into their curricula" (p. 47). Other studies support this pessimistic view of teacher professional development opportunities as well:

> ...there are relatively few opportunities available if measured in financial terms. Overall, there is minimal public investment in formal opportunities for professional development for practicing teachers. Most school districts spend only between 1 and 3 percent of their operating budgets for professional development, even with salaries factored in. This lack of investment in personnel is unheard of either in leading corporations or in schools in other countries... (Bransford et. al. 1999, p. 192)

This limit in teacher capacity to engage in technology professional development is especially apparent as a reform scales to implementation across multiple schools within a school district. Blumenfeld et al. (2000) attempted a systemic reform of an urban school district in Detroit, Michigan. While their professional development model called for after school meetings, workshops, and extensive technical support from the University of Michigan, the authors found that they overestimated the willingness of teachers to do extra planning time for the innovation.

Many did not read the curriculum carefully and were inadequately prepared for instruction. In addition, teachers had infrequent attendance at work sessions and even canceled appointments for classroom visits. So technology reform partnerships, designed for developing communities of practice on small scales within a research school, may encounter resistance in a district wide implementation.

While partnerships and communities of practice may eventually prove to be effective as these research communities refine their models to larger communities, the reality exists that any technology reform that attempts to scale to a district wide implementation will require a professional development plan that supports teachers who do not have the capacity to participate in comprehensive workshops and implementation meetings. Under minimal professional development conditions, the teacher's interaction with the technology itself can become an important catalyst for changing teacher practice. For example, the WISE technology in the computer lab appears to encourage the kinds of student centered individual attention from the teacher that is needed for monitoring student understanding and promoting knowledge integration. This student centered teacher response on the three WISE days occurred without professional development provided by researchers and contrasts with his "self-motivating" groups on day four and five in his own classroom.

In addition, possible technology constraints using computers over time point to important areas to focus on in maximizing limited professional development opportunities for teachers. First, the classroom management issues for first-time users of WISE may decrease in time leading to more efficient use of the small group interaction opportunities in consecutive years of use. If this is the case, then professional development can focus on not only pedagogical content knowledge but also on when this knowledge is most optimally applied. It may be that classroom

management constraints in the first year overwhelm attempts at detailed pedagogical instruction. Initial professional development should focus on technical and classroom management issues, easing the initial burdens on technology implementation. As the teacher gains confidence and efficiency with the technology through continued use, the teacher will be better able to attend to the introduction of new teaching strategies and the constructivist principles that support them. Professional development programs should be sensitive to the possible trajectories of teacher progress and introduce the proper content at the most optimal times.

Second, it may also be possible that the classroom management issues remain stable across a variety of teachers and over long trajectories of technology use. In this case, researchers may have to look to how teachers integrate other forms of technology such as microscopes or chemistry labs into their curriculum. It may be possible to look at transfer strategies for moving successful classroom management knowledge from the use of more traditional classroom technologies into the computer lab. However, it may be that technology reforms that were initially designed for research environments where graduate students provide rich pedagogical and technical support may need to be redesigned to work in minimal professional development environments. Researchers may have to reengineer computer-assisted instruction so that it is less dependent on unreliable networks, temperamental software, and constant technical support.

Finally, teachers need the same kind of scaffolds for knowledge integration activities that many technology reforms provide for students. The WISE interface (Figure 1, Appendix 3) reveals the variety of knowledge integration scaffolds that technology can provide students as they progress through a classroom period. Teachers need similar types of "just-in-time" scaffolding to guide teacher pedagogy to desired knowledge integration activities and away from teacher activity choices that may be counter productive to student knowledge integration. For

example, WISE scaffolds student interactions so that students can progress through a unit without constant direction from the teacher. In many cases, students can trace their own independent path through the software looking at evidence and articles of interest to them. This independent scaffolding for students allows the teacher more freedom to work with individual students while the software guides the rest of the class through the unit. However, it is possible that many students may use this independence to engage in activities that increase classroom management related to discipline and require teachers to spend more time attending to procedural or troubleshooting issues. Teacher scaffoids would guide teachers to attend to potential sources of discipline or technology breakdowns and provide the means for minimizing their occurrence. These scaffolds could also encourage changes in teacher pedagogy providing affordances for constructivist teacher practice in the design of the software itself.

Future Directions

The discourse analysis methodology used in this analysis is still a work in progress. It should evolve as the method is applied across more teachers and a greater variety of technology reform implementations. In particular, this study suffers from the amounts of content discourse recorded compared to other forms. Therefore, there are many potential patterns for discourse not covered by the emergent patterns in the current coding scheme, especially in the content area. For example, whole class lecture discussion is probably an effective way to teach elements of knowledge integration such as how to deal with evidence and controversy, however opportunities to code for this type of lecture discussion were not available from the teacher in this study.

Also, I agree with Fishman et al. (2001) when they describe the continued need for studies that determine how technology influences student learning. I intend to use the discourse methodology developed here to analyze student interactions and link these interactions to patterns

in teacher practice. Folding student interactions into the analysis would also allow me to leverage the large amounts of work on student learning outcomes already done under the WISE and SKI research agendas.

Continued development of the methodology should eventually lead to a reliable method for quantifying teacher and student practice within technology reform classrooms. As researchers using this methodology change their analysis to include not only reforms in classrooms but also reforms in schools and whole school districts, they will have quantifiable results they can aggregate and scale with them as their research foci scales outward. This is a necessary step as research moves from asking how technology influences student learning to how we can enable large groups of teachers to use the rich fruits of current student cognitive research.

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Appendix 1 Coding Scheme

Discourse Audience:

Whole Class
The segment of discourse is directed at the class as a whole. The discourse may include questions or responses directed at individuals if the exchange is meant to be heard by the class as a whole.

Individual/Small Group
The segment of discourse is directed at an individual or small group of students.

Discourse Categories:

Not Talking
A period where the subject does not talk. Small pauses within discourse segments are ignored. Silence between discourse segments is coded if longer than 5 seconds.

Unrelated Topics to Course Classroom Management or Course Content
Discourse that does not fall under the discourse categories of Classroom Management or Content.

Classroom Management (Discipline)
Discourse related to correcting student misbehavior in the classroom.

Classroom Management (Discovery of Functionality)
Discourse related to discovering previously unknown functionality in a piece of technology. If the teacher did not know there was a chat activity in a software curriculum and discovers it during class, this discourse would fall under this category.

Classroom Management (Introduction)
Discourse related to introducing a new topic or new classroom activity to students. The students should be encountering the topic or activity for the first time. If the teacher is reintroducing a topic or activity from a previous class, this discourse should go under the category of status maintenance instead. This section is usually a short opening prelude at the beginning of class foreshadowing the day's activities or content. It is often followed immediately with either procedural activity discourse or more specific content discourse.

Classroom Management (Locating Information)
Discourse related to locating a specific piece of information using classroom materials. For example, a teacher may remember that a certain piece of evidence exists but not its location in a piece of software curricula.

Classroom Management (Organizing Student Groups)
Discourse directed toward the logistics of workgroup formation and maintenance.

Classroom Management (Procedure)
Discourse related to explaining an activity process for the first time. For example, a teacher explaining a computer logon procedure to students would fall under this category. Procedures related to Organizing Student Groups should be placed in the Organizing Student Group category. Procedures related to Reporting/Organizing Grades should be placed in the Reporting/Organizing Grades category. Procedures that are explained for the second and subsequent times should be placed in the Maintaining Student Progress category.

Classroom Management (Reporting/Organizing Grades)
Discourse directed toward the logistics of reporting grades to students or collecting and managing previously completed student assignments.

Classroom Management (Maintaining Student Progress)
A teacher performs this discourse as they check on student progress within an activity or provide spontaneous clarification of already stated procedures to maintain student progress. For example, if the teacher had already explained the logon procedure to the class, then explaining the procedure again multiple times during the class period would fall under this category.

Classroom Management (Summary)
Discourse related to summarizing material and activities already completed that day to end the classroom period. This is usually a short period of discourse just before the end of the period to ensure that the students leave the class with a few important points in their minds.

Classroom Management (Troubleshooting)
Discourse related to solving problems with technology unrelated to incorrect student procedures. For example, teacher discourse to help students whose web page is loading very slowly or to help students when the printer runs out of ink would fall under this category.

Content (Argument)
Discourse related to defining what an argument is or how to improve an existing argument.

Content (Controversy)
Discourse related to making students aware of multiple viewpoints on an issue or encouraging students to support one side or the other on a controversial issue.

Content (Evidence)
Discourse related to defining what evidence is and how to collect and organize it.

Content (Lecture)
Discourse normally associated with didactic teaching styles. The teacher has a set of course content items that he explains to the whole class as a group. The discourse can be interrupted with student questions, however the teacher always returns to the set of content items he wants to explain to students. Students are not engaged in any activity except listening to the lecture. For example, a teacher may list important events in the history of some subject and tell the students what happened in each event. Lectures given on Argument, Controversy, Evidence, Relevancy, or Validity would have been coded as a separate category, not here (no lectures of these types were observed). This would provide an opportunity to divide this category further into content transfer or metacognitive areas.

Content (Lecture Discussion)
Similar to the Lecture discourse described above except that the teacher involves the students in the lecture with questions directed toward students. The questions often only require students to respond with a sentence or two sometimes repeating lecture material already covered. The basic pattern of the teacher explaining a set of content items while the class listens is maintained. Lecture Discussions given on Argument, Controversy, Evidence, Relevancy, or Validity could have been coded as a separate category (no lecture discussions of these types were observed). This would provide an opportunity to divide this category further into content transfer or metacognitive areas.

Content (Prompting)
The teacher asks a question of a student that requires the student to integrate new information with their own ideas often leading to a reorganization of their understanding. Prompting occurring within lecture discussions would be coded here.

Content (Providing Answers)
The teacher responds to a student question by providing an answer or explanation. Only teacher answers outside of Lectures or Lecture Discussions are coded as Providing Answers.

Content (Relevancy)
The teacher makes a connection between student experience or interests and the material in the classroom.

Content (Validity)
The teacher makes the student aware of differences in the sources of evidence as they relate to student arguments. In this type of discourse, the teacher equips the student to critique evidence as to its applicability to the argument and validity compared to other sources.

Appendix 2 Data Charts

Day Location	One Computer Lab	Two Computer Lab	Three Computer Lab	Four Teacher Classroom	Five Teacher Classroom	Six Teacher Classroom
Primary Activity	Whole period in WISE	Whole period in WISE	Whole period in WISE	Lecture followed by student groups preparing for presentations	Teacher reports grades while student groups prepare for presentations	Whole period with students giving their group presentations

Chart 1 Summary of Six-Day Instructional Sequence

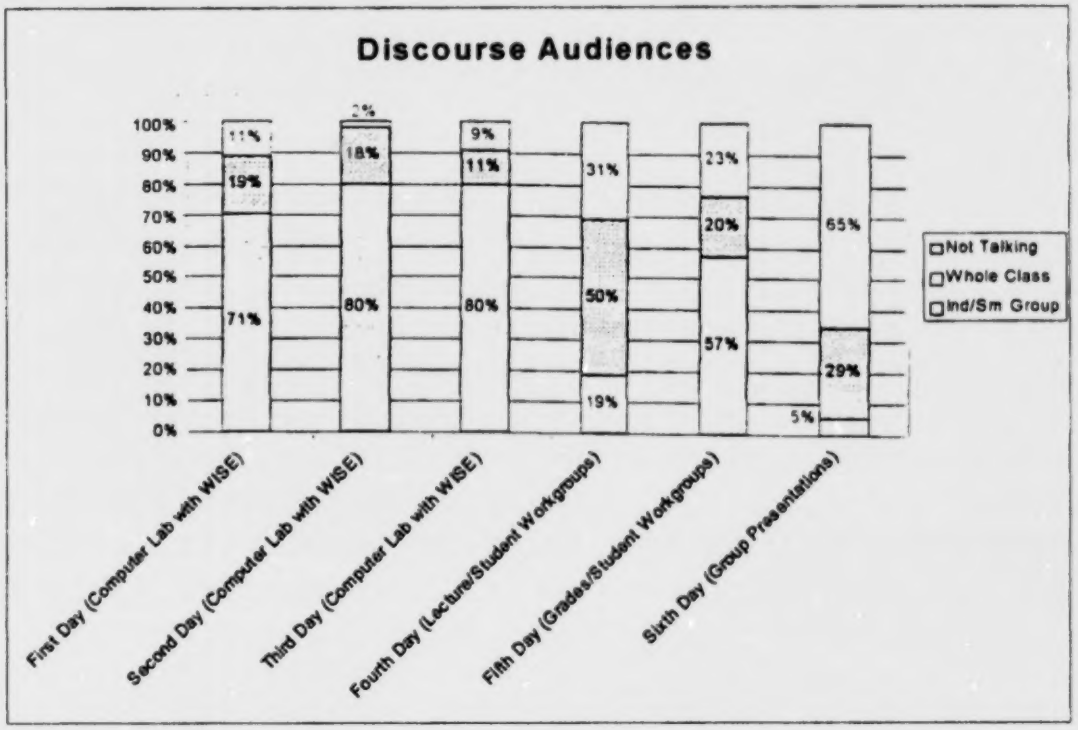

Chart 2 Discourse Audiences

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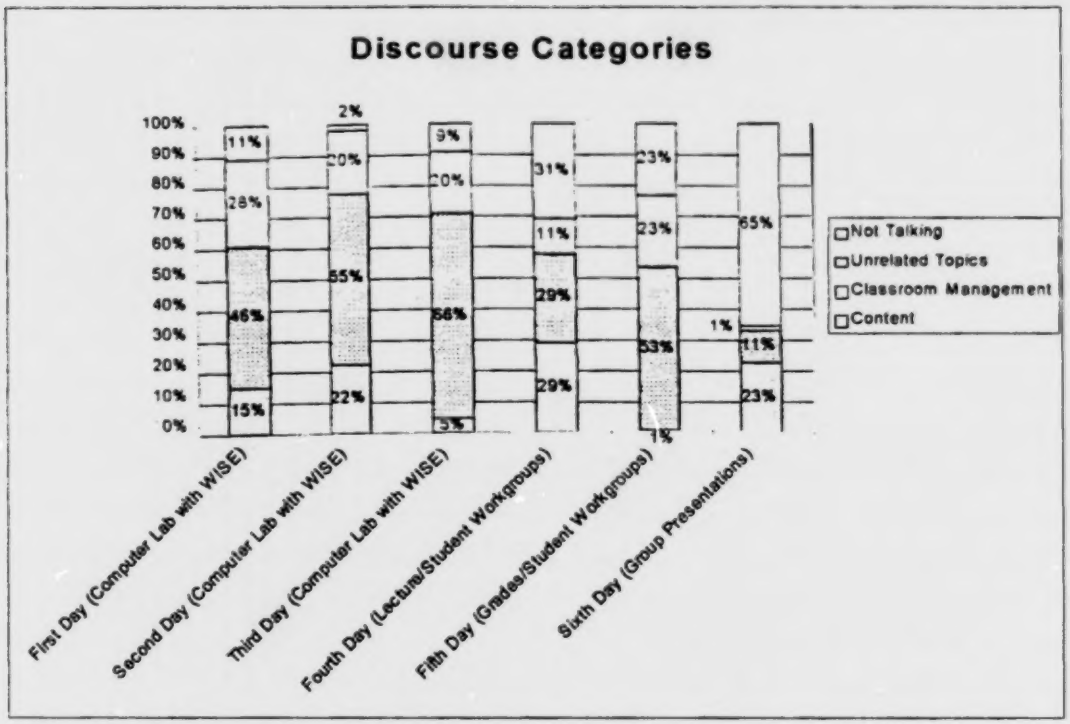

Chart 3 Discourse Categories

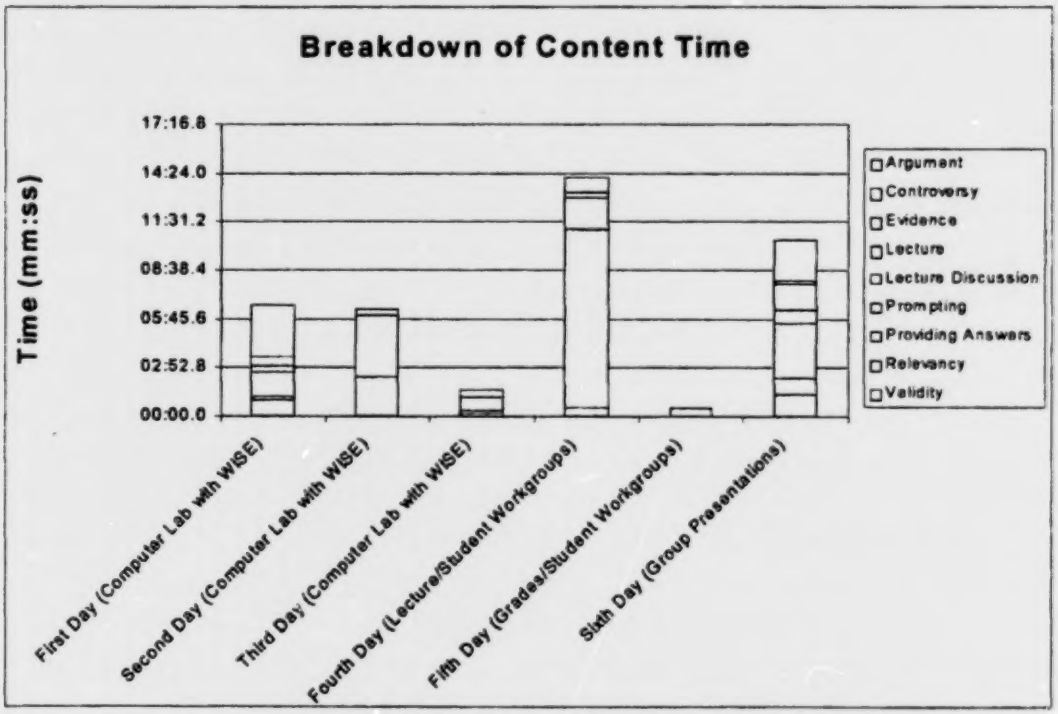

Chart 4 Breakdown of Content Time

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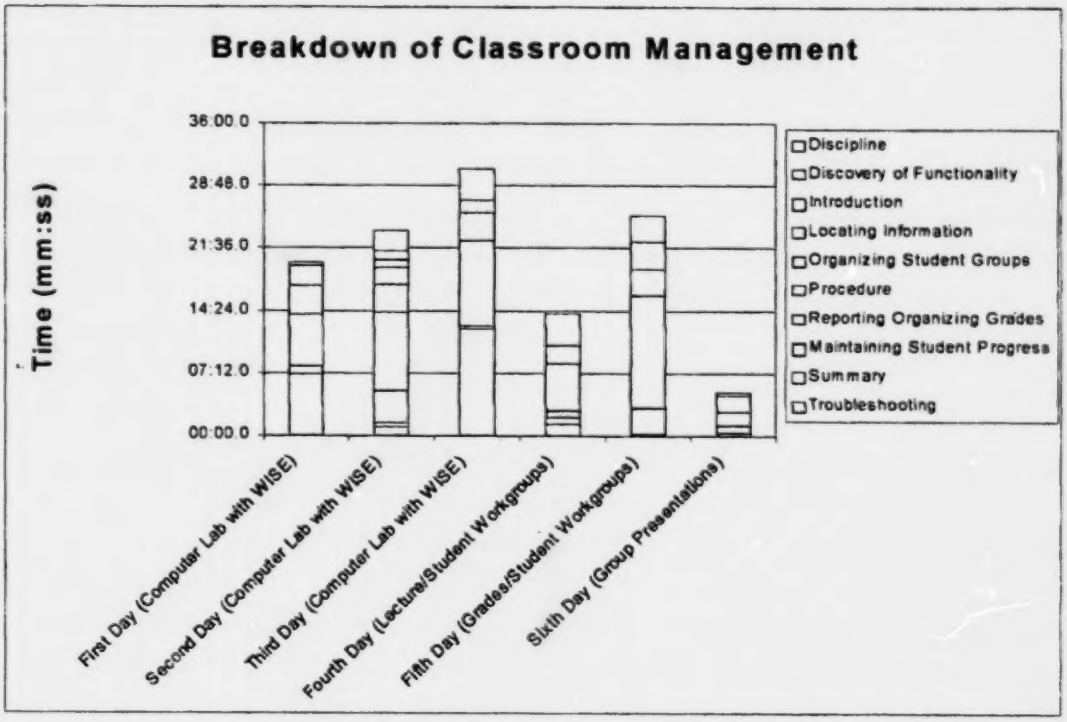

Chart 5 Breakdown of Classroom Management

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Appendix 3 Figures

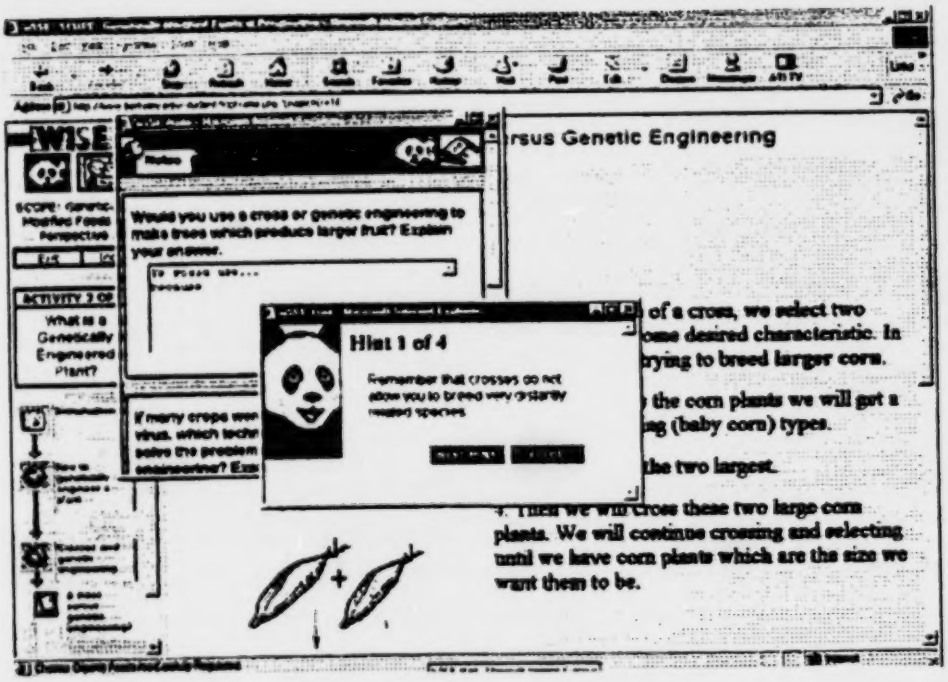
WISE
rsus Genetic Engineering
Would you use a cross or genetic engineering to make trees which produce larger fruit? Explain your answer.
Hint 1 of 4
of a cross, we select two
ome desired characteristic. In
rying to breed larger corn.
the corn plants we will get a
ag (baby corn) types.
the two largest.
plants. We will continue crossing and selecting until we have corn plants which are the size we want them to be.

Figure 1 Sample Screen from WISE

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